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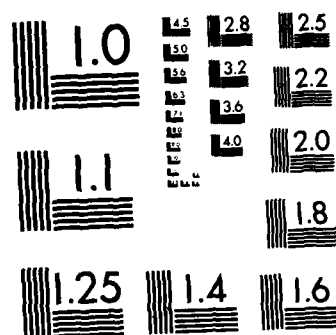
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DEFENSE COMMUNICATIONS ENGINEERING CENTER

TECHNICAL NOTE NO. 13-82

ACCESS LINE ENGINEERING
COMPUTER PACKAGE

OCTOBER 1982

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER TN 13-82	2. GOVT ACCESSION NO. AD-A126 368	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ACCESS LINE ENGINEERING COMPUTER PACKAGE	5. TYPE OF REPORT & PERIOD COVERED Technical Note	
7. AUTHOR(s) F. Kopf	6. PERFORMING ORG. REPORT NUMBER	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Defense Communications Engineering Center Operations Research Branch R821 1860 Wiehle Ave Reston VA 22090	8. CONTRACT OR GRANT NUMBER(s)	
11. CONTROLLING OFFICE NAME AND ADDRESS (Same as 9)	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS N/A	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) N/A	12. REPORT DATE October 1982	
	13. NUMBER OF PAGES 10	
	15. SECURITY CLASS. (of this report) Unclassified	
	18. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A	
16. DISTRIBUTION STATEMENT (of this Report) A. Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) N/A		
18. SUPPLEMENTARY NOTES Review relevance 5 years from submission date.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Usage Peg Count Overflow Traffic Load Sizing Grade of Service		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This document describes the methodology used in the development of the Access Line Engineering Computer Package. Both software used in the data preparation and in the analysis are also discussed.		

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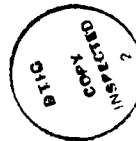
OCTOBER 1982

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FOREWORD

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I. INTRODUCTION

The Access Line Engineering Computer Package is the aggregation of software that is used to analyze and resize the CONUS AUTOVON access area. Previously, two methods have been used to engineer the CONUS AUTOVON access area: one proposed by AT&T Longlines and the other developed by the Traffic Engineering and Analysis Branch of the Defense Communications Agency (DCA). Since the discrepancies between these two methods were significant, the Traffic Engineering and Analysis Branch of DCA Headquarters enlisted DCEC's help in standardizing the access area engineering methods[1]. Subsequently, DCEC developed its own method which appears more accurate than either of the two previous methods[2].

The Access Line Engineering Computer Package is a computer model that incorporates the model developed by DCEC along with a command list (CLIST) which ultimately provides the user with the capabilities of:

- Resizing the various PBX's in the CONUS AUTOVON access area.
- Editing data and resizing a variable number of PBX's in the foreground.
- Producing a report that may be used by DCA Headquarters for their semiannual report.

The steps of access line engineering are:

- a. Load Determination
- b. Retry Adjustment
- c. System Sizing.

The purpose of this document is twofold:

- a. To explain the various systems that exist and how the software developed deals with these systems, and
- b. To detail how the software interacts with the model through a command list.

The following section directly relates to TN 22-81 [2], which describes the performance and resizing algorithms incorporated in the access area engineering system. However, TN 22-81 details a complete analysis for only one specific case. There are presently nine different cases that comprise the existing CONUS AUTOVON access line configurations. The access area engineering system possesses the capability of predicting the performance of and analyzing any type of configuration currently in the CONUS AUTOVON access area.

The third section details the software that was developed in this computer package, that is, the various computer programs used in conjunction with the access line engineering analysis.

Finally, section IV is a summary of our findings and the conclusions of our study.

II. SYSTEM CONFIGURATIONS IN THE CONUS AUTOVON ACCESS AREA

The base configuration of a typical CONUS AUTOVON access area in the Defense Communications System (DCS) is shown in Figure 1.

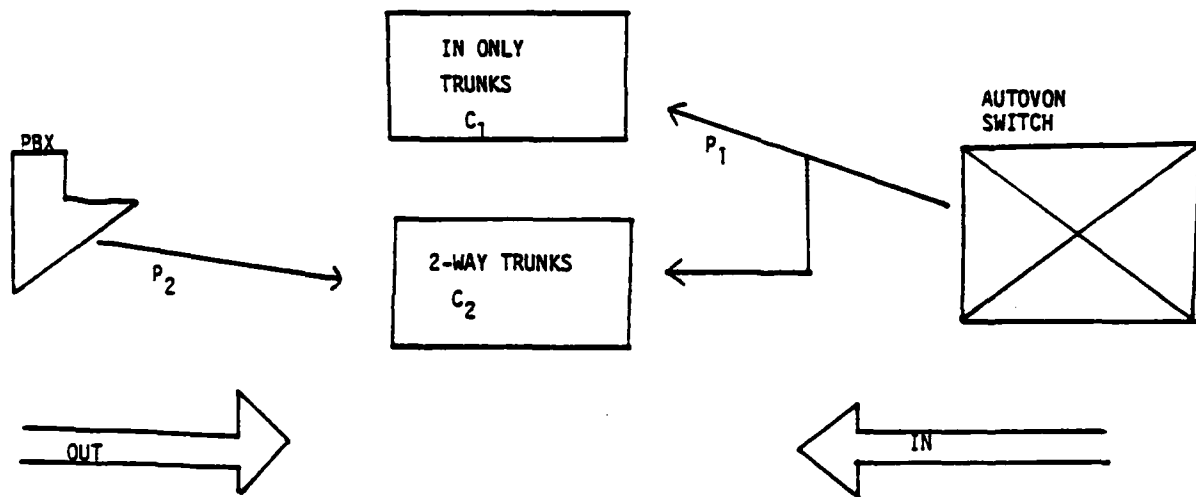


Figure 1. Typical CONUS AUTOVON Access Area

The calls traveling from an AUTOVON switch to the PBX are termed IN calls. The calls trying to get from the PBX to the AUTOVON switch are referred to as OUT calls. Typically, the IN calls first attempt to seize the in-only lines; if all those trunks are busy it will then try to seize a two-way trunk. A call that is blocked on both of these trunk groups is lost. The OUT calls may only seize the two-way trunks. In this system, the IN calls have accessibility to a greater number of trunks than do the OUT calls and will thus obtain a better grade of service.

In order to properly analyze any access area, as we said in section I, three basic steps must be followed:

- a. Load Determination
- b. Retry Adjustment
- c. System Sizing.

The load determination step is designed to obtain accurate measurements of both the inward and outward traffic in the access area. This traffic is measured in erlangs and is called the inward offered load (P_1) and the outward offered load (P_2). In the CONUS AUTOVON access area, it became readily apparent that there are various combinations of system configurations and available data. This necessitated the use of alternative methodologies in the load determination step. These methodologies are discussed in subsection 1 of this section.

The retry adjustment step is needed to account for the calls that are initially blocked but then tried again. The initial offered loads that contain those calls called retries, must be adjusted to account for this factor.

The third and final step of the AUTOVON access area analysis is the system sizing step. In this step, the adjusted loads are used to determine the current inward and outward grades of service (percentages of calls being blocked inward and outward). We then determine the combination of in-only, out-only, and two-way lines that will meet a specified grade of service requirement. One such requirement is that the desired inward grade of service be $P.05$ and the outward grade of service be $P.10$; that is, 5 percent of the IN calls and 10 percent of OUT calls are lost.

As will be shown, the retry adjustment and system sizing are the same once the IN and OUT loads are determined. The variations of system configurations and available data necessitated the development of several methods to deal with various cases in determining the loads.

1. LOAD DETERMINATION

As previously stated, the predominant type of CONUS AUTOVON access area system includes both in-only and two-way lines. We will refer to this as the "base system". However, the base system given may not always include all of the possible data elements; therefore, various subsystems arise. The known data may include any (or all) of the following: the total usage (in CCS), the usage on the in-only lines (in CCS), usage on the two-way lines (in CCS),

usage out (in CCS), peg count out (PCO), peg count in (PCI), peg count into the two-way lines (PCI2W), and overflow (OFL) all in number of calls. There are different subsystems, though, that incorporate the same load determination techniques as one another. This will be pointed out in the description of these subsystems.

If one defines a "subsystem" to be a configuration of channels along with the known data that traverses it, there are presently eight subsystems in the CONUS AUTOVON access area. The base system consists of the five subsystems which are described in a. through e. The other subsystems represent the variations of both the channel configuration and the given data.

The simplest cases for the base system are those which have the property of having all of the needed data known (PCI2W, PCI, OFL, usage on the two-way lines, usage on the one-way lines) and the overflow equal to zero. That is, all of the calls received service.

a. Subsystem 1: Base System With Overflow Equal to Zero. If the value for the peg count into the two-way lines is zero, then the blocking that the one-way (in only) lines see ($P_{BINON} = \frac{PCI2W}{PCI}$) is zero;

thus all of the IN traffic is being carried on the in-only lines. We may therefore say that the two-way lines are only being used to carry OUT traffic. We may then use the usage figures for the inward and outward load determinations as follows (dividing by 36.0 to convert from CCS's to erlangs):

$$\text{Inward } P_1 = \frac{\text{usage on one-way lines}}{36.0} \quad (1)$$

$$\text{Outward } P_2 = \frac{\text{usage on two-way lines}}{36.0} \quad (2)$$

If, however, there is a value other than zero for the peg count into the two-way lines ($P_{BINON} > 0$), then we must find another way to determine the load since the IN traffic is being carried on both the in-only and on the two-way lines. We use a subroutine called PHOER, which solves Erlang's Loss Formula backwards: given the in blocking and the number of in channels, it determines the inward load that gives this blocking.

Next, we must determine the outward load. If we said that the entire usage on the two-way lines was for OUT traffic, we would be estimating the outward traffic to be too high since the two-way lines carry both IN and OUT traffic. The IN traffic offered to the two-way lines is the overflow from the in-only lines. Thus, we may determine the outward load to be the total load on the two-way lines minus the in load on the two-way lines:

$$P_2 = \frac{\text{usage on 2-way}}{36.0} - \frac{PCI2W}{PCI} \times P_1 \quad (3)$$

If this determination for P_2 results in a negative value (due to inconsistent data), we must then try to recalculate the outward load based on different information. There are two possible recalculations, depending on whether the AUTOVON switch is a 4W5 (four-wire five) or is either an ESS or an AECO. This is because the different AUTOVON switches collect different types of data. If the switch is a 4W5 type, we may directly use the usage out data and conclude:

$$P_2 = \frac{\text{usage out}}{36.0} \quad (4)$$

If the switch is either an ESS or an AECO, then the usage out data is not available. However, if the total offered load is defined to be the total usage (divided by 36), then we may take a percentage of this value based on the peg counts to obtain the outward load as:

$$P_2 = \frac{\text{TOTAL USAGE}}{36.0} \times \frac{\text{PCO}}{\text{PCO} + \text{PCI}} \quad (5)$$

In this recalculation, the ratio $\text{PCO}/(\text{PCO} + \text{PCI})$ is the percentage of total traffic that is OUT traffic.

This describes the base system where all of the possible data are known. However, there are cases in the CONUS AUTOVON access area in which all of the pertinent information is not known. Therefore, the load determination steps are given for these cases. Let us examine the base system (as shown in Figure 1) where again the $\text{OFL} = 0$; however, we are now without the information about the usage on the in-only lines.

b. Subsystem 2: Base System With Overflow = 0 and Unknown Usage on the In-Only LINES

(1) Type 4W5 AUTOVON Switch. Since we do not know the separate usage on the in-only and two-way lines, we must use the other information available in order to determine the inward load. The values for the total usage and usage out are given, so we may determine P_1 and P_2 as:

$$P_1 = \frac{(\text{TOTAL USAGE} - \text{USAGE OUT})}{36.0} \quad (6)$$

$$P_2 = \frac{\text{Total Usage}}{36.0} - P_1 \quad (7)$$

(2) Type ESS/AECO AUTOVON Switch. Since the switch is not a Type 4W5, we do not have the usage out as we did in subsystem 2(1). We will, therefore, use the in and out traffic ratios applied to total usage:

$$P_1 = \frac{\text{Total Usage}}{36.0} \times \frac{\text{PCI}}{\text{PCI} + \text{PCO}} \quad (8)$$

The outward load determination may be done as in subsystem 2, equation (7):

$$P_2 = \frac{\text{Total Usage}}{36.0} - \frac{\text{PCI2W}}{\text{PCI}} - P_1.$$

c. Subsystem 3a: Base System with OFL ≠ 0 and the Peg Count into the Two-Way Lines is Known. This case was discussed in TN 22-81 [2]. The inward load is determined as in the second case of subsystem 1 where the subroutine PHOER is used. This case, where the overflow ≠ 0, leads us to the following method. We use, as a measure of the blocking on the in only lines:

$$\text{PBINON} = \frac{\text{Peg Count Into the Two-Way Lines}}{\text{PCI}}.$$

Then we use a computer subroutine that, from the blocking and the appropriate number of channels (numbers of in channels in this case), calculates the value of the load (inward load in this case). However, it is not as easy as before to determine P_2 . As outlined in reference [2], we employ the secant method to find the outward load.

We initially determine a starting value for the outward load, P_2 , by solving Erlang's Loss Formula in reverse, using the measured blocking on the two-way lines (subroutine PHOVF2). A guess is then made for P_2 by:

$$\hat{P}_2 = \hat{P}_2 - \text{PBINON} \times P_1 \text{ (set } \hat{P}_2 = 0.10 \text{ if } \hat{P}_2 = 0)$$

$$\text{and set } \tilde{P}_2 = \hat{P}_2 - 0.10.$$

We then use the performance algorithm, the subroutine ALPERF. Given the number of lines present and the inward and outward loads, ALPERF derives both the inward and outward grades of service, along with the blockings on the access lines.

Thus, the performance algorithm ALPERF is used with the current outward load \hat{P}_2 to derive a value for the inward grade of service, INGOS. Once again, ALPERF is used with \tilde{P}_2 to return an inward grade of service value INGOS. We will use, as a measure of the overall inward blocking,

$$\text{INBLOCK} = \frac{\text{OFL}}{\text{PCI}}.$$

Now, the derivative is set by using the form:

$$DF = \frac{F(a) - F(b)}{a-b}$$

Therefore,

$$DF = \frac{INGOS - \hat{INGOS}}{\tilde{P}_2 - \hat{P}_2}$$

$$\text{and } P_{21} = \hat{P}_2 - \frac{(INGOS - INBLOCK)}{DF}$$

$$\text{set } \tilde{P}_2 = \hat{P}_2 \quad .$$

We try to match P_{21} to \hat{P}_2 within a tolerance of 0.0001 using the above process in an iterative manner. When this is accomplished, we have found the outward load P_2 .

The base system has one case remaining: the case when the PCI2W is not given.

d. Subsystem 3b: Base System with OFL40 and PCI2W Unknown. In this subsystem our objective is to match the ratio of the carried outward/inward loads to the ratio of the given peg counts (usages if switch is 4W5) outward/inward. In addition, the variable that measures the overall inward blocking, INBLOCK, should be equal to the inward grade of service that we determine, INGOS. Therefore, a method was developed that meets both of these requirements simultaneously. This technique is an iterative process that terminates when both objectives are satisfied.

This method uses two variables based on the initial data, the overall measured inward blocking, INBLOCK, and the adjustment factor:

$$\begin{aligned} \text{ADJ FACTOR} &= \frac{\text{USAGE OUT}}{\text{USAGE IN}} \text{ for 4W5 Switch} \\ &= \frac{\text{Peg Count Out}}{\text{PCI}} \text{ for ESS/AECO Switches} \quad . \end{aligned}$$

We may define a variable, TESTSV, as follows:

$$\text{TESTSV} = \frac{P_2 \times (1 - \text{OUTGOS})}{P_1 \times (1 - \text{INGOS})} \quad .$$

This is the ratio of the carried outward to the inward loads. Therefore, in this method we will strive to match:

- (1) TESTSV to ADJ-FACTOR
- (2) INGOS to INBLOCK.

The procedure begins with the use of the inward load that was determined in subsystem 4a as a starting point for P_1 . We formulate a guess for P_2 as:

$$P_2 = P_1 \times \text{ADJ-FACTOR}.$$

This multiplication is done to keep the offered loads in the proper ratio.

The inward grade of service (INGOS) is then calculated using the performance algorithm ALPERF with the present values of P_1 and P_2 . If the INGOS and INBLOCK are not sufficiently close (within 0.001) then set a variable to be equal to the ratio of the carried traffic:

$$\text{GOS-RATIO} = \frac{1-\text{INGOS}}{1-\text{OUTGOS}} .$$

If INGOS is greater than INBLOCK, the present load produces too little blocking (relative to INBLOCK) and therefore our load figures are not high enough; thus:

$$\begin{aligned} P_1 &= P_1 + \text{increment} \text{ (increment initially} = 1 \text{ erlang)} \\ P_2 &= P_2 \times \text{ADJ-FACTOR} \times \text{GOS-RATIO.} \end{aligned}$$

If INGOS is lower than INBLOCK, the present load produces too much blocking and therefore the loads are too high; so:

$$\begin{aligned} P_1 &= P_1 - \text{increment} \\ P_2 &= P_1 \times \text{ADJ-FACTOR} \times \text{GOS-RATIO.} \end{aligned}$$

We alter P_2 every time we increment P_1 to keep the ratio of the loads as constant as possible. As INGOS and INBLOCK approach each other in value, the magnitude of the increment is decreased.

Once INGOS is matched to INBLOCK, we then try to equalize TESTSV and ADJ-FACTOR, using the loads determined in the previous matching. If TESTSV is less than ADJ-FACTOR, the carried outward/inward load ratio has not yet achieved a high enough value; thus, we must add to the outward load and subtract from the inward load:

$$\begin{aligned} P_1 &= P_1 - \text{increment} \\ P_2 &= P_2 + \text{increment.} \end{aligned}$$

However, if TESTSV is greater than ADJ-FACTOR, just the opposite is true - the carried outward/inward load ratio is too high; thus:

$$\begin{aligned} P_1 &= P_1 + \text{increment} \\ P_2 &= P_2 - \text{increment.} \end{aligned}$$

Once again, the variable $\text{GOS-RATIO} = \frac{1-\text{INGOS}}{1-\text{OUTGOS}}$ is set. Increments are

added and subtracted until TESTSV and ADJ-FACTOR are within 5 percent of one another. Once this 5 percent tolerance is met, the values of INGOS (which has now changed due to the new loads) and INBLOCK are again tested to see if their difference is still bounded by 0.001. If not, then we return to the first procedure of matching INBLOCK and INGOS. Ultimately, we will match both INGOS to INBLOCK and TESTSV to ADJ-FACTOR. If we are unable to satisfy both tests

simultaneously, we explain that the data for this PBX cannot be processed and this system is flagged by the program.

This concludes the load determinations for all of the various subsystems of the base system. In describing the load determination steps for the remainder of the systems, we will - where applicable - refer back to techniques used in the base system.

Let us now examine the case where one-way out lines are the only type of lines in the system.

e. Subsystem 4: One-Way Out Lines Only. Since there are neither in-only nor two-way channels, it is obvious that there is no incoming traffic; thus $P_1 = 0$. The outward load may be determined by solving Erlang's Loss Formula in reverse using the subroutine PHOVF2. This subroutine finds the outward load, given the peg count out (or usage out for 4W5 switches) and the number of out lines.

There are also systems in CONUS AUTOVON where there are in-only lines and no two-way lines.

f. Subsystem 5: Absence of Two-Way Lines. The inward load is determined as in subsystem 1. If there are no out-only channels, then it is clear (since there are no two-way channels) that no out load is possible; $P_2 = 0$. If there are out-only lines, then the outward load is determined as in subsystem 4.

Additionally, there is a system in CONUS AUTOVON where all the lines are two-way lines. Once again, there are various subsystems dependent upon the type of AUTOVON switch and the known data. We will start analyzing this system at its simplest, where the overflow is zero, and the peg count in is zero.

g. Subsystem 6: Only Two-Way Lines With OFL=0 AND PCI=0, and All Pertinent Data Known.

Since the peg count in is zero, we have $P_1 = 0.0$. With the total usage being known, we may easily determine P_2 as:

$$P_2 = \frac{\text{TOTAL USAGE}}{36.0} .$$

Next, examine the subsystems where the OFL $\neq 0$ and/or the PCI $\neq 0$.

h. Subsystem 7: Only Two-Way Lines with PCI $\neq 0$ or OFL $\neq 0$.

(1) Type 4W5 AUTOVON Switch.

If PBINON = 0.0, this signifies that PCI2W = PCI and thus the peg count data cannot be trusted. We therefore use the usage figures to obtain the total load, P TOTAL, as:

$$P \text{ TOTAL} = \frac{\text{TOTAL USAGE}}{36.0} \quad (9)$$

This calculation for P TOTAL is valid also when PBINON = 1.0 (thus PCI2W = PCI) and the overflow is zero.

$$\text{If PBINOU (blocking on two-way lines)} = \frac{\text{OFL}}{\text{PCI2W}} \neq 0$$

then there is overflow in (blocking) the system.

If PBINON = 1.0 when there is overflow, then we may again (using PHOER) solve Erlang's Loss Formula in reverse (using PBINOU) to solve the total load. An additional case that is handled by using PHOER is the subsystem in which PBINON is neither 1 nor 0 (we must use the subroutine since the peg count data alone is not sufficient to determine PTOTAL).

In all the cases of subsystem 7(1), the total load is now split into the inward and outward components via the usage data:

$$P_1 = \frac{(\text{total usage} - \text{usage out})}{\text{total usage}} \times P \text{ TOTAL}$$

$$P_2 = P \text{ TOTAL} - P_1.$$

(2) Type ESS/AECO AUTOVON Switch. If the overflow = 0, then the total load is determined as in subsystem 7(1), equation (9). If the overflow $\neq 0$, then the total load is determined by using the subroutine PHOER.

Once again, since we have determined the total offered load, we need to determine the inward and outward components. We split the load by taking a percentage of the total load based on peg counts:

$$P_1 = \frac{\text{PCI}}{\text{PCI} + \text{PCO}} \times P \text{ TOTAL}$$

$$P_2 = P \text{ TOTAL} - P_1.$$

i. Subsystem 8. All Three Types of Lines Present (In-Only, Out-Only, Two-Way).

Finally, there is the system where all three types of lines are present - in-only, out-only, and two-way lines. In CONUS AUTOVON, there are very few cases of this type, and they basically split into two subsystems:

(1) All Three Types of Lines with PCI2W Known. The inward load is determined in exactly the same way as it was for the base system subsystem 1.

The outward load is determined in the same way as it was for the out-only system, subsystem 4.

(2) All Three Types of Lines with PCI2W Unknown. If the PCI2W is unknown, then we are dealing with a system very similar to the base system where the PCI2W is unknown. Therefore, both the in and out loads are determined as in subsystem 3b of the base system.

2. RETRY ADJUSTMENT

It is necessary to account for calls that are initially blocked but do not leave the system. These calls are called retries (or reattempts). The initial offered loads that were determined must be reduced so that we have an accurate measure of the traffic. Therefore, both the inward and outward loads are adjusted to account for this retry factor through the use of engineering constants [2].

However, this initial adjusted out load must be readjusted depending on the outward grade of service that is desired. Thus, if we are resizing (final step) for a P.10 out then:

$$\text{adjusted outload} = \text{initial adjusted outload} (1 + 0.6 \times \text{PBOU}^*)$$

where PBOU* is the desired out grade of service (P.10 in this case).

As explained in the next section, there is one additional resizing grade of service requirement, that of P.05 inward without regard to the outward grade of service. Thus, for this case, we arrive at the adjusted outload by multiplying by the final outward grade of service realized:

$$\text{adjusted outload} = \text{initial adjusted outload} (1 + 0.6 \times \text{final OUTGOS}).$$

3. SYSTEM SIZING

This is the final step of the CONUS AUTOVON access area analysis. The sizing involves the use of the performance algorithm ALPERF. Using the adjusted loads, and the current system configuration, we use ALPERF to examine the current grades of service. The sizing basically entails the adding or subtracting of channels (in-only and two-way lines) until the desired grades of service are met. There are two sizing methodologies which were incorporated:

a. Maximize the total carried traffic and achieve a desired blocking on the in-only lines while meeting the grades of service requirements.

b. Maximize the IN traffic and minimize the total number of channels while meeting the grades of service requirements.

The three grades of service requirements, which are required for the final document, are presented in the following subparagraphs:

a. P.05 In/P.10 Out. This GOS requires that we design the system so that the PBX experiences blockage of no more than 5 percent of its incoming calls and 10 percent of its outgoing calls. Thus, the new system we have designed will have the configuration necessary to insure the P.05/P.10 requirement.

After resizing for P.05/P.10, an additional sequence of tests are also executed. These "grades of service tolerance" tests involve removing one two-way line from our designed reconfiguration, and using ALPERF to determine the new "inward and outward" grades of service.

Two tests are then performed:

$$\text{If } \frac{\text{TRIAL INGOS} - 0.05}{\text{TRIAL INGOS} - \text{Reconfigured INGOS}} \leq 0.30$$

$$\text{and } \frac{\text{TRIAL OUTGOS} - 0.10}{\text{TRIAL OUTGOS} - \text{Reconfigured OUTGOS}} \leq 0.30$$

then we accept the trial configuration as the recommended system. In effect, we are seeking to approximate the P.05/P.10 requirement, and the subtraction of one line may leave us sufficiently close to this requirement in some cases.

b. P.05 In/P.XX Out. This case is only studied when the initial INGOS is worse than 0.05. This requirement says we are designing the system to possess a P.05 GOS inward, without regard to the value of the outward grade of service. This objective is achieved by continually adding to the original number of in-only lines (one at a time) until the inward GOS of P.05 is met, while leaving the number of 2-way lines the same. The final value of the OUTGOS is determined by calling ALPERF when the P.05 GOS is met. Since only the INGOS is crucial here, only the first "grade of service tolerance" test (for INGOS) is used.

c. P.05 In/P.20 Out. This grade of service requirement is only studied when the initial configuration possesses an outward grade of service worse than P.20. We then resize the access area to achieve P.05/P.20. As in the P.05/P.10 objective, we examine the resized configuration in terms of its "grades of service tolerance" tests. The only difference is that P.20 is used as our initial OUTGOS in our tests (instead of P.10).

III. SOFTWARE

Seven software programs and two IBM utilities were used in conjunction with the Access Line Engineering Computer Package:

Software Programs

- (1) PPACC1
- (2) AGGREG
- (3) MATCH
- (4) SETDATA
- (5) SIZING
- (6) MAXTRAF
- (7) FORMAT

IBM Utilities

- (1) IEBGENER
- (2) SORTD

1. DATA PREPARATORY SOFTWARE

The first problem encountered in using the Access Line Engineering Computer Package was that of the structure of the original data provided by ATT. The format of this information is complex and nonuniform. In fact, before any analysis could be attempted, it was necessary to properly aggregate and format this data. Thus, two software programs, PPACC1[3] and AGGREG, were developed.

PPACC1 is designed to read the initial ATT data base (one month of data) and to delete any headings or nonessential information that is present. Therefore, only the necessary data elements are left after PPACC1, in terms of either identification or computational value.

However, the data that relates to one PBX may physically exist on distinct records in the data base. It was then decided that in order to properly analyze the access area, the data would have to be aggregated; the AGGREG program aggregates and structures the data. The software becomes quite detailed due to the numerous different "hunting schemes" of different switches along with different system configurations. As an example, there are completely different hunting sequences for ESS, AECO, and 4W5 switches. In turn, for different configurations within each switch there are different aggregation policies. Therefore, AGGREG is a case-by-case testing of the PBX in order to ascertain its proper data aggregation.

The third program to be implemented was MATCH, developed to select PBX's from the ATT data base which DCA desires to study. These were placed in a DCA data base. In addition, the DCA data base was corrected with respect to the PBX location names and phone exchanges.

The final preparatory program developed was SETDATA. This was developed to combine several months of data into one common data base. Thus, one may

analyze several months of data simultaneously by formulating arithmetic averages. The resulting output of this software is a new data base with average values for every PBX to be studied in the CONUS AUTOVON access area.

2. ANALYSIS SOFTWARE

The tools for the analysis are located in the program modules SIZING and MAXTRAF. These modules offer two different approaches to the resizing philosophy, but are identical in their load determination steps. Thus, depending on the user's needs, the user may select either module.

The software for both of these modules comprises three basic sections. The initial section checks the data for its validity and completeness. If the data are insufficient or incorrect, the PBX is identified and printed without any further computations.

The second section calculates the inward and outward offered loads for the PBX being studied. Due to the large number of different systems, the coding of this section is detailed. In addition, the offered loads are reduced to account for retries - calls that were initially blocked but do not leave the system.

The third section is that part of the code which is responsible for the engineering of the present access area. Two sizing philosophies were studied. The program SIZING implements the philosophy of maximizing the total traffic and achieves a desired blocking on the in-only lines while meeting the desired inward and outward grades of service. The program MAXTRAF implements the philosophy of maximizing the total incoming traffic (incoming to PBX) and minimizing the total number of channels while meeting the desired inward and outward grades of service.

The program FORMAT was used to construct the layout of the semiannual report, as requested by the Traffic Engineering and Analysis Branch of the DCA.

The IBM utilities IEBGENER and SORTD were used to transfer data from tape to disc and to sort the data.

IV. SIGNIFICANT FINDINGS AND CONCLUSIONS

In September 1981, DCA Headquarters published its semiannual access area engineering report. Those PBX's that were engineered by DCA Headquarters were also studied at DCEC by means of the Access Line Engineering Computer Package. In fact, DCA Headquarters has expressed great satisfaction with this automated system. The amount of time needed to do this task has been greatly reduced by this automated system. It is now possible by submitting one computer run (or two smaller runs) to completely analyze the entire CONUS AUTOVON access area in less than three minutes of CPU time.

In addition, the incorporation of the interactive CLIST, EDIT1 in the Access Line Engineering Computer Package permits resizing PBX's, editing data, and producing a report usable by DCA Headquarters for their engineering report.

REFERENCES

- [1] DCA Letter, Traffic Engineering and Analysis Branch, 25 May 1979, "Standardized Access Line Engineering."
- [2] DCEC TN 22-81, "An Investigation of Access Area Engineering Methods for AUTOVON," M.J. Fischer, August 1981.
- [3] DCEC Code R821, DCEC Computer Program PPACC1, D. Calabrese.

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